Science

Module 9

Earth Science: Earth and the Solar System

Module Goal

The goal of this module is to provide information that will help educators increase their knowledge of grade-appropriate science concepts, knowledge, and skills to support effective planning or modification of their existing science instructional units for students with significant cognitive disabilities. The module includes important concepts, knowledge, and skills for the following instruction:

- The Universe (middle) – The cosmos is vast and explored well enough to know its basic structure and operational principles.
- Forces in Nature (middle) – Everything in the universe exerts a gravitational force on everything else; there is an interplay between magnetic fields and electrical currents.

Module Objectives

The content module supports educators' planning and implementation of instructional units in science by:

- Developing an understanding of the concepts and vocabulary that interconnect with information in the module units.
- Learning instructional strategies that support teaching students the concepts, knowledge, and skills related to the module units.
- Discovering ways to transfer and generalize the content, knowledge, and skills to future school, community, and work environments.

The module provides an overview of the science concepts, content, and vocabulary related to Earth Science: Earth and the Solar System and provides suggested teaching strategies and ways to support transference and generalization of the concepts, knowledge, and skills. The module does not include lesson plans and is not a comprehensive instructional unit. Rather, the module provides information for educators to use when developing instructional units and lesson plans.

The module organizes the information using the following sections:

I. Science Academic Standards and Related Alternate Assessment Targets and Underlying Concepts;
II. Scientific Inquiry and Engineering Design;
III. Connecting Concepts;
IV. Vocabulary and Background Knowledge information, including ideas to teach vocabulary;
V. Overview of Units' Content;
VI. Universal Design for Learning (UDL) Suggestions;
VII. Transference and Generalization of Concepts, Knowledge, and Skills; and
VIII. Tactile Maps and Graphics.

Section I

Science Academic Standards and Related Alternate Assessment Targets and Underlying Concepts

It is important to know the expectations for each unit when planning for instruction. The first step in the planning process is to become familiar with the identified academic standards and related Alternate Assessment Targets (AATs) and Underlying Concepts (UCs) covered in the module. The AATs are specific statements of knowledge and skills linked to the grade-specific science academic standards. The UCs are basic key ideas or concepts linked to specific AATs. UCs are a basis for developing a more complex understanding of the knowledge and skills represented in the AAT and should not be taught in isolation. It is important to provide instruction on the AAT along with the UC in order to move toward acquisition of the same concepts, knowledge, and skills.

Table 1 includes the academic standards and related AATs and UCs for Earth Science: Earth and the Solar System. While only the academic standards targeted for the Tennessee Comprehensive Assessment Program/Alternate (TCAP/Alt) are included, instruction on additional standards will aid in student understanding. Standards that are not included still represent important content for students to master. Therefore, the AATs and UCs included in the table do not cover all of the concepts that can be taught to support progress and understanding aligned to the standards.

Table 1. Science Academic Standards and Related AATs and UCs [1]

Academic Standards	Alternate Assessment Targets (AAT)	Underlying Concepts (UC)
The Universe: *The cosmos is vast and explored well enough to know its basic structure and operational principles.*		
0607.6.3 Distinguish among a day, lunar cycle, and year based on the movements of the earth, sun, and moon.	Identify an Earth-sun model, which demonstrates that Earth's orbit around the sun corresponds to a calendar year, and an Earth-moon model that demonstrates that the moon's orbit around Earth corresponds to approximately one month.	Identify the positions, using an Earth-sun model, which shows day and night.
0607.6.6 Use a diagram that shows the positions of the earth and sun to explain the four seasons.	Identify an Earth-sun model, which demonstrates that Earth's tilt and orbit around the sun cause changes in seasons.	Identify characteristics of the four seasons.
0607.6.7 Explain the difference between a solar and a lunar eclipse.	Recognize a solar eclipse as the result of the moon casting a shadow over Earth.	Recognize the movement of an object's shadow on the ground at different times on a sunny day.

Academic Standards	Alternate Assessment Targets (AAT)	Underlying Concepts (UC)
Forces in Nature: *Everything in the universe exerts a gravitational force on everything else; there is an interplay between magnetic fields and electrical currents.*		
0807.12.6 Illustrate how gravity controls the motion of objects in the solar system.	Understand how the Earth orbits the sun (i.e., gravity can make a smaller object orbit a larger object).	Understand that objects in the solar system move in a regular and predictable way.

[1] Instruction is not intended to be limited to the concepts, knowledge, and skills represented by the AATs and UCs listed in Table 1.

Section II

Scientific Inquiry and Engineering Design

It is important for students with significant cognitive disabilities to have the opportunity to explore the world around them and learn to problem solve during science instruction. This approach to science instruction does not involve rote memorization of facts, rather it involves scientific inquiry. A Framework for K-12 Science Education (2012) unpacks scientific inquiry, providing eight practices for learning science and engineering in grades K – 12. These practices provide students an opportunity to learn science in a meaningful manner. Students should combine the science and engineering practices as appropriate to conduct scientific investigations instead of using a practice in isolation or sequentially moving through each practice. Support should be provided as necessary for students with significant cognitive disabilities to actively use the practices. See Section VI. Universal Design for Learning Suggestions for support ideas. Following are the eight science and engineering practices (National Research Council, 2012) with added examples.

Science Practices

- Asking questions (for science) and defining problems (for engineering).
  Examples: What causes day and night on Earth? Why is it daylight longer in the summer than in the winter? What causes the moon to look different throughout the month? What keeps Earth in its orbit around the sun? Does Mars have seasons?
- Developing and using models.
  Examples: Use a model to show that Earth travels in an orbit around the sun and corresponds to a calendar year. Create a model illustrating the position of the moon and Earth during the lunar cycle. Develop a model that illustrates a solar eclipse.
- Planning and carrying out investigations.
  Examples: Conduct an investigation to discover what causes shadows of stationary objects to move throughout the day. Experiment with a flashlight and globe of Earth to understand the relationship between Earth's tilt, the most direct and intense solar energy, and warmer weather.
- Analyzing and interpreting data.
  Examples: Use data showing the type of moon (e.g., full, gibbous, quarter, crescent, new) over a month to identify a pattern. Create a bar graph showing the length of day (i.e., sunrise to sunset) over time to illustrate the change due to Earth's orbit around the sun. Use a model to describe what a given phenomenon might look like without gravity.

- Using mathematics and computational thinking.
  Examples: Measure the distance between the sun, Earth, and Earth's moon on a model built to scale. Measure the height of a shadow based at different times of the day. Use computation to determine elapsed time from sunrise to sunset each day in order to determine the length of days growing longer or shorter. Indicate the accuracy of size and distance (scale) relationships within the Earth-moon-sun model, including any scale limitations within the model.
- Constructing explanations (for science) and designing solutions (for engineering).
  Examples: Explain the relationship between the moon's orbit around Earth using a lunar cycle model. Design a pinhole projector and explain why it is a safe way to view a solar eclipse. Describe the relationships and interactions between components of the solar system, including gravity as an attractive force between objects.
- Engaging in argument from evidence.
  Examples: Use reasoning to connect the relevant and appropriate evidence to construct an argument explaining the cause of the seasons on Earth. Use appropriate evidence to explain why the sun has a stronger gravitational force on Earth than Earth does on the sun.
- Obtaining, evaluating and communicating information.
  Examples: Effectively communicate information from reliable sources on the gravitational pull of the sun causing Earth's orbital cycle. Describe how to determine a position on Earth from which the moon or sun can be viewed (depending on the type of eclipse). Describe the shape of Earth's orbit.

Science Practices Resources[1]

- This site categorizes inquiry into three types: structured inquiry, guided inquiry, and open inquiry. Each type provides a wide range of example lessons grouped by elementary and middle school. http://www.justsciencenow.com/inquiry/
- NASA provides a listing of websites for educators. https://www.nasa.gov/audience/foreducators/Alpha_index.html and http://sunearthday.nasa.gov/2006/educators/lp_68.php
- A variety of sites that provide information on experiments, models, and simulations:
  - Earth-sun model and Earth-moon model. http://www.sciencealive.co.nz/sites/default/files/Model%20earth%20sun%20moon.pdf
  - scale model of the sun and Earth – http://sunearthday.nasa.gov/2007/materials/solar_pizza.pdf
  - equinox and solstice model – http://solar-center.stanford.edu/activities/Suntrack-Model/Suntrack-Model.pdf
  - solar and lunar eclipse models – http://www.scienceinschool.org/2012/issue23/eclipses

Section III

Connecting Concepts

Grade-level science content includes Connecting Concepts, which are concepts that connect information between different science strands and grade levels. The Connecting Concepts are intended to work together with the science inquiry and engineering practices, in addition to core content, to enable students to reason with evidence, make sense of phenomena, and design solutions to problems. Helping students make connections between these types of concepts and new content information supports comprehension of the concepts, knowledge, and skills as well as transference and generalization (see

[1] The resources in this module may change over time and no longer be available.

Section VII for more information). Connecting Concepts that are specific to this module connect to content across the units within the module as well as across modules.

Connecting Concepts are a common link between multiple standards and units of study. The Connecting Concepts, by being revisited and linked to multiple units of study, become a strong foundation of understanding and support the students in learning new concepts. For example, students may understand that patterns can be used to identify cause-and-effect relationships such as Earth's rotation and day/night; the tilt of Earth in relationship to the sun and the seasons; and Earth's orbit around the sun and gravitational forces. Some Connecting Concepts may apply across multiple content areas and instructional emphases (e.g., understanding scale in mathematics by using a model of Earth, sun, and moon).

Teaching Connecting Concepts

The following strategies pulled from the principles of UDL (CAST, 2011) are ways in which to teach Connecting Concepts to help students understand the concepts and make connections between different curricular content. During instruction, highlight:

- patterns (e.g., Illustrate the pattern of the lunar cycle.),
- critical features (e.g., Emphasize key element(s) in a visual Earth-sun model.),
- big ideas (e.g., Highlight the relationship between Earth's rotation on its axis and day/night.), and
- relationships (e.g., Show the relationship between the tilt of Earth and the seasons.)

For example, when learning about seasons, present a model showing the tilt of Earth during each season and the directness and intensity of the solar energy on the Northern Hemisphere. In addition, build connections between familiar and new information (e.g., Relate instruction to the types of activities and type of dress typical for each season).

Following are **Connecting Concepts** for this Content Module – Earth Science: Earth and the Solar System.

Patterns

- Patterns can be used to determine similarities and differences.
- Patterns in rates of change and cycles can be used to make predictions.
- Patterns can be observed and used as evidence.
- Patterns can be used to identify cause-and-effect relationships.

Cause and Effect

- Events that occur together with regularity might or might not have a cause-and-effect relationship (e.g., How do the changing positions of the moon, Earth, and the sun cause spring tides or neap tides?).
- Some events that occur together are correlated versus causal relationships.
- Some phenomena may have more than one cause.
- Cause-and-effect relationships may explain change.

Scale, Proportion, and Quantity

- Natural objects and observable phenomena exist from the very small to the immensely large.
- Standard units can be used to measure and describe physical quantities such as weight, time, temperature, and volume.
- Models using scale can be used to study systems that are too large or too small.

- Proportional relationships can be used to gather information about the magnitude of properties.

Systems and System Models

- A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot.
- System parts work together.
- A system can be described in terms of its components and their interactions.

Connecting Concept Resources:

Grant Wiggins talks about "big ideas" in this article.
http://www.authenticeducation.org/ae_bigideas/article.lasso?artid=99

A Framework for K-12 Science Education, Appendix G explains the crosscutting concepts and how the concepts help students deepen their understanding of the information.
http://www.nextgenscience.org/sites/default/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Teacher Vision provides ten science graphic organizers that are free and printable.
https://www.teachervision.com/graphic-organizers/science/52539.html

Utah Education Network provides a variety of student interactives for:

- grades three through six. http://www.uen.org/3-6interactives/science.shtml
- grades seven through twelve. http://www.uen.org/7-12interactives/science.shtml

Section IV

Vocabulary and Background Knowledge

Vocabulary is critical to building an understanding of science concepts, knowledge, and skills. The vocabulary words that students gain through experiences provide ways for students to comprehend new information (Sprenger, 2013). Students can better understand new vocabulary when they have some background knowledge to which they can make connections. In addition, learning new vocabulary increases students' background knowledge. Therefore, it is important to teach vocabulary purposely when introducing new concepts, knowledge, or skills (e.g., lunar cycle) and in the context of the specific content (e.g., Teach the terms new moon, full moon, quarter moon, gibbous moon, crescent moon, waxing, and waning when teaching about the moon's orbit around Earth.).

This module includes two types of vocabulary words, both equally important to teach. The first type, **general vocabulary words,** labels groups of words that generalize to a variety of animals, plants, organisms, and activities. For example, understanding the meaning of the word "season" helps students understand the word during instruction or conversation on the four seasons, types of activities and clothing for specific seasons, etc. The second type, **specific content words,** represents groups of words that are associated with an organism, system, process, or phenomena. Specific content words (e.g., solar eclipse, solar energy) connect to general words, such as orbit. Providing exposure and instruction on general words provides background knowledge when introducing corresponding or related specific words.

Key Vocabulary for Instructional Units

Table 2 and Table 3 contain lists of key general vocabulary words and specific content words that are important to the units in this module. The vocabulary words span across grades three through eight; refer to the TN science standards for grade-specific words. Teach general vocabulary words to the student using a student-friendly description of the word meaning (e.g., Solar is something related to or given by the sun.) and an example of the word (e.g., The sun is the center of our solar system.). Teach the specific content vocabulary using a student-friendly description of the word meaning (e.g., A gibbous moon looks bigger than a quarter moon and smaller than a full moon.) and a possible connection to a general vocabulary word (e.g., The gibbous moon is part of the lunar cycle.).

Do not teach memorization of vocabulary words; instead, place emphasis on understanding the word as a result of observation, investigation, viewing a model, etc. For example, a student should be able to identify a shadow or what causes a shadow instead of defining the word "shadow."

Table 2. General Vocabulary Words

General Vocabulary – words that generalize to different animals, plants, organisms, and activities. Describe the word and provide examples (e.g., gravity – the force from the sun that keeps Earth in its orbit).

• axis	• lunar	• orbit	• star
• calendar	• mass	• planet	• sun
• cycle	• model	• revolve	• temperature
• day	• month	• rotate	• tilt
• Earth	• moon	• scale	• waning
• energy	• night	• season	• waxing
• forces	• North Pole	• solar	• year
• gravity	• North Star	• solar system	

Table 3. Specific Content Words

Specific Content Words - words that specify a particular thing (e.g., Earth) or phenomenon (e.g., lunar eclipse).

Describe the word and when possible make the connection to a Connecting Concept (e.g., Summer is a season that is usually hot. Summer is caused by the tilt of Earth and its orbit around the sun.)

• autumn	• new moon	• solstice/equinox
• crescent moon	• Northern Hemisphere	• Southern Hemisphere
• Earth	• orbital plane	• spring
• equator	• orientation	• summer
• full moon	• quarter moon	• sun
• gibbous moon	• reflect	• winter
• lunar cycle	• satellite	
• lunar eclipse	• solar eclipse	
• moon	• solar system	

Ideas to Support Vocabulary Learning

Table 4 includes ideas and examples for teaching vocabulary in ways to build conceptual understanding of the words.

Table 4. Ideas to Teach Vocabulary Effectively (Marzano, 2004)[1]

Ideas	Examples
Explain, describe, and/or give examples of the vocabulary word rather than formal definitions.	Provide a description and an example of solar eclipse, "An eclipse happens when the moon moves between Earth and the sun."
Have students restate the vocabulary word in their own words. Take this opportunity to help students connect new vocabulary, especially general vocabulary, to prior knowledge.	Have students state the seasons and describe in their own words (verbally or using alternative and augmentative communication [AAC] system) characteristics of the seasons.
Have students represent vocabulary words in a variety of ways (e.g., pictures, symbols, graphic organizers, or models).	• Have students complete a graphic organizer by writing the word, drawing or pasting a picture of the word, describing the word, and using the word in a sentence. See Figure 1. Science Vocabulary Graphic Organizer for an example. • Have students view words paired with pictures and recorded definitions: ○ lunar cycle (e.g., https://quizlet.com/128217123/lunar-cycle-flash-cards/), ○ gravity (e.g., https://quizlet.com/126017503/gravity-flash-cards/), and ○ eclipse (e.g., https://quizlet.com/130691509/eclipse-flash-cards/).
Provide multiple exposure to vocabulary words in a variety of ways. This does not suggest mass trials, rather distributed trials in different ways or contexts. Reference http://projectlearnet.org/tutorials/learning_trials.html for information on learning trials.	• Expose students to vocabulary by incorporating it into daily activities such as talking about the current season, the moon phase, shadows, etc. • Read books or watch videos related to the vocabulary and concepts: ○ Earth's axis, rotation, and revolution (e.g., http://bookbuilder.cast.org/view.php?op=view&book=102276&page=1),

Ideas	Examples
	○ lunar phases (e.g., http://bookbuilder.cast.org/view.php?op=view&book=20939&page=1), and ○ gravity (e.g., https://www.youtube.com/watch?v=4yyb_RNJWUM). • Have students complete online vocabulary activities (e.g., https://flashcards.engrade.com/unitthreevocab587 or http://www.cram.com/flashcards/games/earth-science-the-sun-vocabulary-5382).
Ask students to discuss the vocabulary words with each other.	• Have students share a definition or description of a word and have others guess the word. • Have students share their representations (e.g., drawings or pictures) of a word with each other.
Play vocabulary word games with students.	• Have students play online vocabulary game (e.g., https://www.eduplace.com/kids/hmsc/activities/ewordgame/index.html?grade=1&unit=a&chapter=2). • Have students work with an interactive word wall (e.g., http://nstacommunities.org/blog/2013/10/16/putting-science-words-on-the-wall/).
Have students watch a dramatization or have them act out the vocabulary term.	Have students simulate Earth's orbit around the sun, Earth's rotation, and the moon's orbit around Earth.

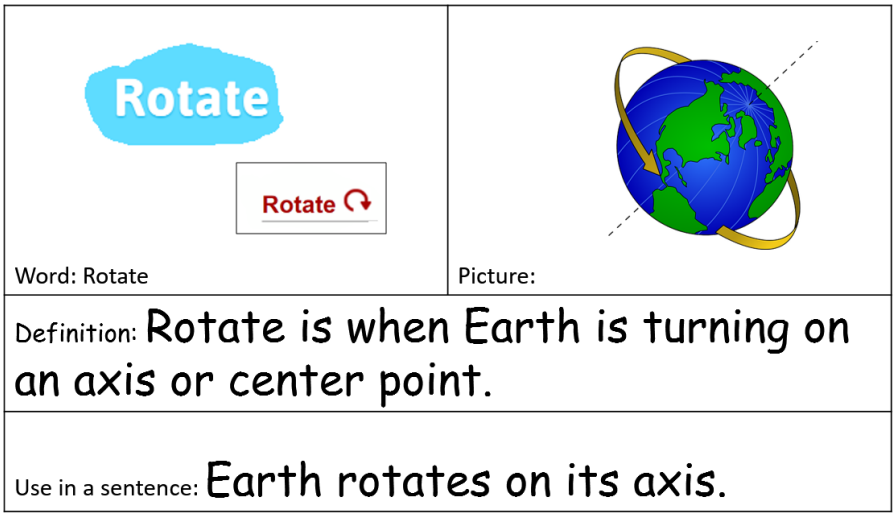
[1] Refer to Section VI, Universal Design for Learning (UDL) Suggestions for additional instructional strategies.

Vocabulary Example

Have students complete a vocabulary graphic organizer by writing a vocabulary word, representing it with a picture, describing what it means, and using it in a sentence (see Figure 1). The activity can be modified as needed for individual students. For example, one student may copy the word while another student may cut the printed word from a newspaper and paste it onto the graphic organizer. One student may draw the picture while another student cuts a picture and pastes it onto the graphic organizer. One student may complete a digital version using an adaptive keyboard. Two National Center and State Collaborative (NCSC) resources are available and may prove helpful:

- Use systematic instruction as described in the NCSC Instructional Guide. https://wiki.ncscpartners.org
- Reference ideas in the NCSC Vocabulary and Acquisition Content Module. https://wiki.ncscpartners.org

Figure 1. Science Vocabulary Graphic Organizer



Vocabulary Resources:

Vocabulary.com provides explanations of words using real-world examples. Once signed in, an educator can create word lists for students. http://www.vocabulary.com/

Text Project provides Word Pictures that are free for educators to use. It includes word pictures for core vocabulary and various content areas including science and social studies. This link will take you to the Word Pictures page where you can select the category of words you want to use. http://textproject.org/classroom-materials/textproject-word-pictures/

This site provides effective strategies for teaching science vocabulary. http://www.learnnc.org/lp/pages/7079

The Science Penguin site provides ideas to teach science vocabulary. The vocabulary demonstration activity uses real objects to teach vocabulary terms. http://thesciencepenguin.com/2013/12/science-solutions-vocabulary.html

This site provides a wide range of science graphic organizers, including some that are vocabulary specific. http://www.actedu.in/wp-content/uploads/2016/03/Science-Graphic-Organizers.pdf

Section V

Overview of Units' Content

This section of the module contains additional content and references to support educators' understanding and instruction of the instructional units. The information reflects important content to address the AATs and to build students' knowledge, skills, and abilities; however, it is not exhaustive and should be expanded upon as appropriate.

The Universe (middle) – The cosmos is vast and explored well enough to know its basic structure and operational principles.

Content:

- Earth rotates on its axis once each day (approximately 24 hours) and causes day and night.
- The moon travels on its orbit around Earth a little less than once a month (approximately 27 days).
- One complete revolution of Earth around the sun is called a year.
- Seasons have observable characteristics.
- The sun is the source of light energy for Earth and the moon.
- The tilt of Earth on its axis along with its orbital pattern around the sun causes the seasons.
- Earth maintains the same relative orientation in space, with its North Pole pointed toward the North Star throughout its orbit.
- The moon revolves around Earth and rotates on its own axis.
- The phase of the moon you see depends on how much of the sunlit side of the moon faces Earth.
- Shadows on the ground of objects remaining in the same location change due to the movement of Earth.
- A lunar eclipse is caused by Earth casting a shadow over the moon.
- A solar eclipse is caused by the moon casting a shadow over Earth.
- The shadow cast over the moon or Earth has two parts: umbra and penumbra.
- Earth-sun and Earth-moon models can demonstrate movement patterns and resulting phenomena (e.g., day, year, month, seasons, and eclipses).

Forces in Nature (middle) – Everything in the universe exerts a gravitational force on everything else; there is an interplay between magnetic fields and electrical currents.

Content:

- All objects have a gravitational attraction to each other.
- Weight is a measure of the force of gravity on an object, and mass is a measure of the amount of matter an object has.
- The mass of the objects and the distance between them affect the gravitational pull.
- Gravity keeps Earth in orbit around the sun.
- Gravity keeps the moon in orbit around Earth.
- Astronomy is the study of the moon, stars, and other objects in space.
- The force of gravity acts between all objects in the universe.
- Even though a satellite is pulled downward by gravity, it stays in orbit because it is moving so quickly.
- Earth's surface curves away from the satellite at the same rate a satellite falls.

Unit Content Resources:

Earth-sun and Earth-moon Relationships

- NASA has an activity using shadows to build understanding of Earth's movement. http://sunearthday.nasa.gov/2007/materials/changing_shadows.pdf
- NASA provides a lesson that has students actively modeling the movement of Earth around the sun. http://sdo.gsfc.nasa.gov/assets/docs/Kenestetic_Astronomy.pdf
- This site has tasks regarding the Earth-sun relationship. https://sites.google.com/a/spartanpride.net/middle-school-science/7th-grade-science/sun--earth
- Middle School Science has a hands-on activity on the sun, Earth, and moon. https://middleschoolscience.com/2015/01/18/where-is-the-moon-where-is-the-sun-hands-on-activity/
- SPACE.com has information on how the moon phases work. http://www.space.com/6650-moon-phases-work.html
- SPACE.com provides information on the moon's orbital and rotational patterns. http://www.space.com/24871-does-the-moon-rotate.html
- Stanford Solar Center has activities around the moon phases. http://solar-center.stanford.edu/activities/MoonPhases/

Seasons

- NASA has information on Earth's tilt and seasons. http://spaceplace.nasa.gov/seasons/en/
- PBS Learning Media provides a lesson plan on seasons on Earth. http://ket.pbslearningmedia.org/resource/ess05.sci.ess.earthsys.lp_seasons/seasons-on-earth/
- This site provides information on the tilt of Earth and the seasons. http://www.budgetastronomer.ca/index.php?page=th-tilt-of-the-earth-and-the-seasons

Solar and Lunar Eclipse

- Science in School provides a lesson plan with hands-on activities on eclipses. http://www.scienceinschool.org/2012/issue23/eclipses
- SERC has lesson plans on phases and eclipses of the moon. https://serc.carleton.edu/sp/library/guided_discovery/examples/moon_phases.html
- Mr. Eclipse has information and images on eclipses for beginners. http://www.mreclipse.com/Special/SEprimer.html and http://www.mreclipse.com/Special/LEprimer.html

Gravity and the Solar System

- CK-12 provides information on gravity in the solar system. http://www.ck12.org/book/CK-12-Earth-Science-Concepts-For-Middle-School/section/2.3/
- Space Place has information on why planets travel on an orbit the sun, including hands-on activities. http://spaceplace.nasa.gov/review/dr-marc-solar-system/planet-orbits.html
- This site provides information and graphics explaining the cause of a planet orbiting in space. http://www.qrg.northwestern.edu/projects/vss/docs/space-environment/1-what-causes-an-orbit.html

Section VI

Universal Design for Learning (UDL) Suggestions

Three principles of UDL guide development of instruction, instructional materials, and assessments to provide access to learning to the widest range of students. Students with significant cognitive disabilities, especially students with visual and/or hearing impairments and students with complex communication needs, require additional scaffolds, adaptations, and modifications to access content and support learning. The three principles of UDL establish a framework for providing these. UDL provides guiding principles to create instructional materials and activities in a flexible manner to address the needs of different types of learners. Additionally, the flexibility allows for further individualization. Table 5 provides strategies and examples for the UDL Principle I, **Multiple Means of Representation**: presenting information in a variety of ways to address the needs of different types of learners. Table 6 provides strategies and examples for the UDL Principle II, **Multiple Means of Action and Expression**: providing a variety of ways for students to interact with the instructional materials and to demonstrate understanding. Table 7 provides strategies and examples for the UDL Principle III, **Multiple Means of Engagement**: providing a variety of ways to engage and motivate students to learn.

These strategies can assist all students in understanding the basic concepts. Some of the examples include adaptation ideas for students with vision, hearing, and/or physical limitations. Each example has a code to indicate when it includes specific adaptation ideas for these needs:

V = visually impaired (low vision, blind, or deaf-blind)
H = hearing impaired (deaf, hard of hearing, or deaf-blind)
P = physical disability (limited use of hands)

Table 5. Instructional strategy ideas using the UDL Principle: Multiple Means of Representation

Multiple Means of Representation	
Strategies	**Examples**
Introduce information through a multi-sensory approach (e.g., auditory, visual, tactile).	Have students create separate models of Earth's orbit around the sun, Earth's rotation on its axis, and the moon's orbit around Earth (e.g., http://digital.nsta.org/publication/?i=212724&article_id=1730470&view=articleBrowser&ver=html5#{"issue_id":212724,"view":"articleBrowser","article_id":"1730470"}). Create and have students explore a tactile model showing the relationship between the sun and Earth and Earth and the moon (e.g., http://www.perkinselearning.org/accessible-science/sun-earth-moon-system-model). **V** Have students listen to a podcast about the moon or gravity (e.g., http://www.astronomyforkids.com.au/). **H**
Model content through pictures, dramatization, videos, etc.	Watch videos on: • The moon's orbit around Earth and the lunar phases (e.g., https://www.youtube.com/watch?v=f4ZHdzl6ZWg) and • The reason for the seasons (e.g.,

	https://www.youtube.com/watch?v=Pgq0LThW7QA). Provide visuals when explaining a concept (e.g., day and night) or steps in a process (e.g., solar eclipse). **H** Have students participate in kinesthetic and visual experiences illustrating the effect of the sun's gravity on Earth's orbit (e.g., http://spaceplace.nasa.gov/review/classroom-articles/gravityassist.pdf). **V/H/P**
Present information using modified graphic organizers (e.g., simplified organizers with pictures) and models (e.g., tactile and pictures).	Use a KWHL to help students make connections between what they already **K**now, **W**hat they want to know, **H**ow they can find out, and finally, what they **L**earn. (slide show explaining the use of the KWHL chart and how it was made accessible for students with significant cognitive disabilities: http://www.cehd.umn.edu/nceo/teleconferences/tele14/CourtadeFlowers.pdf). **V/H/P** Have students place pictures of the phases of the moon in the correct order on a graphic organizer (e.g., http://sciencewilmeth5.wikispaces.com/file/view/5T4U2A02+Moon+Phases+Graphic+Organizer.doc or http://www.whsd.k12.pa.us/userfiles/1666/Classes/21126/Moon%20phases%20combined.pdf). Create a digital version and have students drag and drop the images into the correct position. **P** Present a model of Earth orbiting the sun (e.g., http://www.classzone.com/books/earth_science/terc/content/visualizations/es0408/es0408page01.cfm).
Provide appropriate and accessible text on the content for students to listen to or read.	Paraphrase information to reduce text difficulty and length (e.g., http://textcompactor.com/) and write or type with a bold and plain font (e.g., Verdana, 18 pt. font) with good spacing between lines (e.g., 1.5 vs. single spacing). **V** Provide students with online text (e.g., https://macmillanmh.com/ccssreading/imagineit/grade6/ccslh_g6_st_4_1a_l1.html). Use a screen reader. **V**
Teach information using songs.	Have students listen to songs about the lunar phases (e.g., http://www.teachjunkie.com/sciences/21-super-activities-teaching-moon-phases/). Have students play the songs using adapted switch. **P** Teach a poem about a solar eclipse (e.g., http://sciencepoems.net/sciencepoems/solareclipse.aspx).

Table 6. Instructional strategy ideas using the UDL Principle: Multiple Means of Action and Expression

Multiple Means of Action and Expression	
Strategies	**Examples**
Use assistive technology to allow the student to interact with the instructional materials and content.	Have students use an adapted mouse for online activities showing Earth's rotation (e.g., http://splash.abc.net.au/res/i/L696/index.html) and Earth orbiting the sun (e.g., http://esminfo.prenhall.com/science/geoanimations/animations/01_EarthSun_E2.html). **P** Provide texts online that include a text reader (e.g., http://bookbuilder.cast.org/view.php?op=view&book=44634&page=1).
Present instructional materials in a manner that provides access.	Provide a paper stabilizer (e.g., removable tape or glue, nonslip map, clipboard, etc.) to prevent the paper from moving when the student is drawing, writing, reading, or pasting. **P** Label models with high contrast or tactile print (e.g., http://www.visionaware.org/info/everyday-living/home-modification-/labeling-and-marking/125). **V** Paste paper materials onto craft foam sheets or blocks to ease manipulation. **P**
Provide voice output devices for students to select an answer.	Record correct answers and distractors on a voice output multiple message switch or multiple voice output switches and have students answer questions using the switch. **P** Have students use three switches with generic labels (e.g., a, b, c; red, blue, green; or three different textures) to which they listen, and then select the correct answer. **V/P** Ask questions that can be answered with yes/no or with answer choices.
Provide simulation activities.	Have students view a simulation on: • Earth's orbit around the sun (e.g., http://www.classzone.com/books/earth_science/terc/content/visualizations/es0408/es0408page01.cfm?chapter_no=04), • lunar phases (e.g., http://astro.unl.edu/naap/lps/animations/lps.swf or https://www.explorelearning.com/index.cfm?method=cResource.dspView&resourceid=613), shadows throughout the day (e.g., http://www.harcourtschool.com/activity/science_up_close/317/deploy/interface.html), and • gravity and orbits (e.g., https://phet.colorado.edu/en/simulation/gravity-and-orbits). Have students play online games (e.g., http://science-class.net/archive/science-class/Astronomy/MoonPhases.htm).

Create a digital graphic organizer that allows drag-and-drop.	Have students drag and drop digital pictures of Earth, the sun, and the moon to create a model showing the orbit of Earth and the moon. Use a screen reader and an adapted mouse. **V/P**

Table 7. Instructional strategy ideas using the UDL Principle: Multiple Means of Engagement

Multiple Means of Engagement	
Strategies	**Examples**
Provide a schedule and visual timer.	Provide personal schedules with tangible symbols. Have students select the next activity on the schedule and set the visual timer to indicate how long the student has before a break. Use a first/then schedule (e.g., http://www.autismclassroomresources.com/visual-schedule-series-first-then/).
Vary the challenge and amount of information presented at a time.	Begin with having students identify characteristics of the seasons. Then, introduce that Earth's tilt on its axis and orbit around the sun cause the seasons. Next, explain that the part of Earth that is tilted toward the sun receives more direct sunlight than the part that is tilted away from the sun, making it warmer.
Make connections to topics or activities that are motivating.	Make connections between motivating seasonal activities when learning about the cause of the seasons. Explore Google Moon (e.g., https://www.youtube.com/watch?v=zHJ77RsnFXI).
Allow choices as possible.	Allow students to choose where to sit, who to sit with, etc. Allow students to use preferred communication (e.g., high-tech device, low-tech device, gestures, etc.) to answer questions or participate in class discussion.
Provide opportunities to work collaboratively with peers.	Provide opportunities for students to work in a general education classroom with peers when working on a solar eclipse project.
Teach student self-regulation skills.	Provide communication symbols to request a break or express feelings and model how to use them appropriately. Provide students with stress balls, finger fidgets, etc. Scaffold instruction on using self-regulation skills (e.g., modeling, cueing, fading support).

UDL Resources

The National Center on Universal Design for Learning has a plethora of information on UDL along with examples and resources. www.udlcenter.org

The UDL Curriculum Toolkit provides two applications for science. http://udl-toolkit.cast.org/p/applications/l1

Perkins School for the Blind provides tips for making science accessible.
http://www.perkinselearning.org/accessible-science/getting-started

This Perkins School for the Blind video, 20 minutes long, describes the techniques used to make science accessible for students who are blind and deaf-blind. https://www.youtube.com/watch?v=tpAejot1-Ec

Symbaloo is a free online tool that allows an educator to create bookmarks using icons. It is easy to create and allows an educator to provide students links to sources of information that can be used for specific instructional units.
www.symbaloo.com

This site provides a brief description of Symbaloo and multiple ways to use the online tool.
https://www.theedublogger.com/2014/04/09/11-ways-to-use-symbaloo-in-the-classroom/

Perkins School for the Blind provides information on using tangible symbols to increase communication, create personal schedules, and provide choices.
http://www.perkinselearning.org/videos/webcast/tangible-symbols

DeafTEC has a Lab Sciences ASL video dictionary. https://www.deaftec.org/resources/stem-signs/lab-sciences

Section VII

Transference and Generalization of Concepts, Knowledge, and Skills

For learning to be meaningful for all students, including students with significant cognitive disabilities, it is important to intentionally make connections to future content, real-world application, and college and career readiness skills. For example, students can learn that the way they discover information through observation and investigation can also be used to problem solve daily living tasks. Additionally, the instruction of science concepts, knowledge, and skills may be the catalyst to developing other areas such as needed communication skills, reading/listening comprehension, mathematic skills, age-appropriate social skills, independent work behaviors, and skills in accessing support systems. Table 8 provides instructional ideas to help transfer and generalize concepts, knowledge, and skills and suggested opportunities to embed other skills into instruction.

Table 8. Transfer and Generalization Ideas

Area	Instruction	Opportunity to Embed Skills
Communication	While teaching vocabulary, make connections to real-life or future opportunities to use the words (e.g., discussing a topic with co-workers) or understand the concepts (e.g., while watching a TV show). Sign ASL STEM terms to provide students with vocabulary needed for science labs and future employment.	Use the context of the content area instruction to increase language skills, work on articulation, or access alternative and augmentative communication (AAC) systems.
Reading and Listening Comprehension	Provide information through reading books and articles on science concepts while working on reading comprehension.	Provide practice on communication skills when students are answering questions or telling about the book or article.
Mathematics	Teach measuring and data collection during investigations.	Provide practice on number identification, sequence, relative quantity or size (e.g., which is more?), etc.
Age-Appropriate Social Skills	Make connections between the Connecting Concepts and real-life experiences showing how they can help students make decisions (e.g., understanding that cause-and-effect relationships can predict change helps understand that their behavior affects how others react).	Provide opportunities to work alongside same age peers to practice age-appropriate social skills and serve a vital role in the group.
Independent Work Behaviors	Encourage and reinforce independent completion of tasks to build independent work skills.	Use positive behavior supports to encourage and reinforce independent work skills.
Skills in Accessing Support Systems	Encourage students to ask appropriately for assistance from peers and adults when working on the content.	Use this time to have the student work on behavior and communication skills.

Section VIII

Tactile Maps and Graphics

The maps and graphics guidelines will help create tactile versions of instructional maps, diagrams, models, and timelines to use with students who are blind or deaf-blind. The tactile maps and graphics may be beneficial to other students as well. A tactile graphic is a representation of a graphic (e.g.,

picture, drawing, diagram, map, etc.) in a form that provides access through touch. It is not an exact copy of the graphic. The section provides basic guidance and links to more comprehensive resources.

Importance of Tactile Maps and Graphics

It is important to provide tactile graphics for young readers (BANA, 2010). It helps students understand and gain information when presented with science and social studies concepts, knowledge, and skills. Science instruction often presents diagrams (e.g., water cycle) and two-dimensional models of living and nonliving things (e.g., model of cell) to teach the related concepts. Social studies instruction often uses maps and timelines to illustrate where and when people existed and events occurred. The following guidance includes information to build upon when creating tactile graphics.

Tactile Graphic Guidance

1. **Determine need for graphic:** When encountering graphics in instructional materials, determine if the graphic is essential to understanding the concept. The Braille Authority of North America (2010) provides a decision tree to help in this determination. It can be accessed online at http://www.brailleauthority.org/tg/web-manual/index.html by selecting "Unit 1 Criteria for Including a Tactile Graphic."
2. **Consult with the local educator trained to work with students with visual impairments.**
3. **Determine the essential information in the graphic.** Read the surrounding information and the caption to determine which information in the graphic to exclude. For example, a map to illustrate location of key countries would not need state lines and capital cities and may not need all of the surrounding countries.
4. **Reduce unnecessary detail in the graphic.** Identify details that are not necessary for interpreting the information in the graphic. For example, a model of the water cycle may show crevices on the mountains, leaves on a tree, and waves in an ocean. Eliminate unnecessary details, as they are difficult to interpret tactilely.
5. **Remove frames or image outlines if they serve no purpose.** Ensure that all lines are necessary (e.g., line that indicates a body of water), and remove any that are not.
6. **Modify the size of the graphic.** Modify the graphic as needed to reduce clutter and allow a blank space between adjacent textures. Additionally, consider the size of the student's hand.
7. **Use solid shapes as feasible.** When solid shapes do not clearly represent the information, use clear solid lines.
8. **Systematically teach exploration and interpretation of tactile graphics.** Systematic instruction and repetition are important when teaching a student to understand a tactile graphic. Pairing the tactile graphic with a 3-dimensional object may help (e.g., pair a raised line drawing of a pencil, an example of goods, with a pencil).

Specific Graphic Type Guidance

Following is information for specific types of graphics that may support instruction in science and social studies.

Graphic Organizers/Concept Maps

- It is best to present information to compare or make connections in a tactile graphic. A tactile graphic presents the information in a spatial display and aids in comparison better than a list.

Diagrams/Models

- Limit the number of areas, lines, and labels. Having more than five makes interpretation difficult.
- Consider pairing a tactile graphic with a 3-dimensional model.

Timelines

- Present timelines in the same direction every time (i.e., horizontal or vertical).

Maps

- Distinguish water from land using a consistent background texture for the water.
- Align the direction of the compass rose arrows with the lines of longitude and latitude on the map.

Creating Tactile Graphics

Following are some ways to create tactile graphics. Additional information can be found at www.tactilegraphics.org.

Commercial products:

- Capsule paper or swell paper – print
- Thermoform

Textured shapes can be made from:

- Sticky back textured papers found at craft stores
- Corrugated cardboard
- Fabric with texture (e.g., corduroy, denim)
- Silk leaves
- Cork
- Felt
- Vinyl
- Mesh tape (used for drywall)
- Sandpaper

Raised lines can be made from:

- Glue (best not to use water-based glue)
- Wax pipe cleaners

Resources

Creating Tactile Graphics, created by the High Tech Center Training Unit, provides basic principles of tactile graphics, characteristics of good tactile graphics, the planning process, guidelines for designs, and more. http://www.htctu.net/trainings/manuals/alt/Tactile_Graphics.pdf

The Texas School for the Blind and Visually Impaired provided basic principles for Preparing Tactile Graphics, element arrangement on a tactile graphic, resources for preparing quality graphics, etc. http://www.tsbvi.edu/graphics-items/1465-basic-principles-for-preparing-tactile-graphics

Perkins School for the Blind has short videos that explain the importance of tactile graphics and information on spatial relationships and graphic literacy, moving from models to graphics, and strategies for reading tactile graphics. http://www.perkinselearning.org/videos/webcast/teaching-tactile-graphics

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Picture Citations

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Prepared by edCount, LLC in collaboration with Educational Testing Service as part of the TCAP/Alt Science and Social Studies contract.